Possible future strategies to limit extend and impact of major system disturbances

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iTesla
Innovative Tools for Electrical System Security within Large Areas

Possible future strategies to limit extend and impact of major system disturbances

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Leader of iTesla WP6 – Defense and restoration

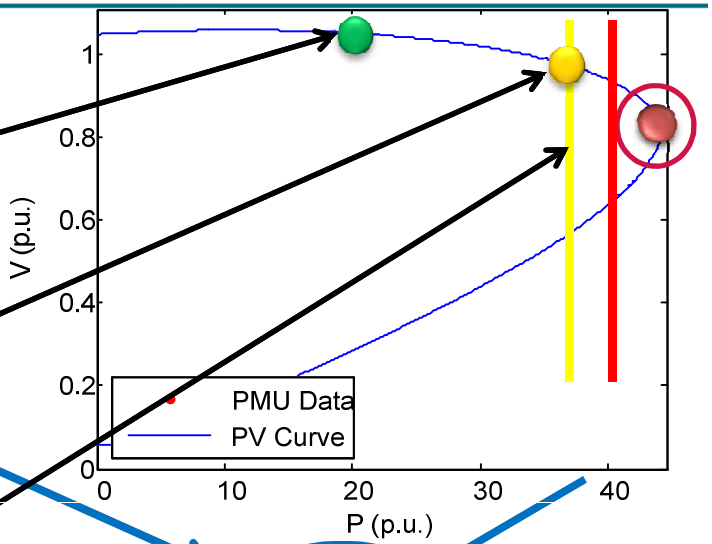
Background

- Reasons to revise / upgrade defense and restoration:
  - Pan European trading: increased loading of transmission / interconnection
  - Increased penetration of renewables
  - Increased distributed generation / flexible consumption
  - Improved technology
    - Power: Facts ...
    - Communication: WAMS ...

Defense and restoration

supplement to iTesla platform

Monitor the Operating Point:
Tools for Pan-European Observality help to identify the system's state

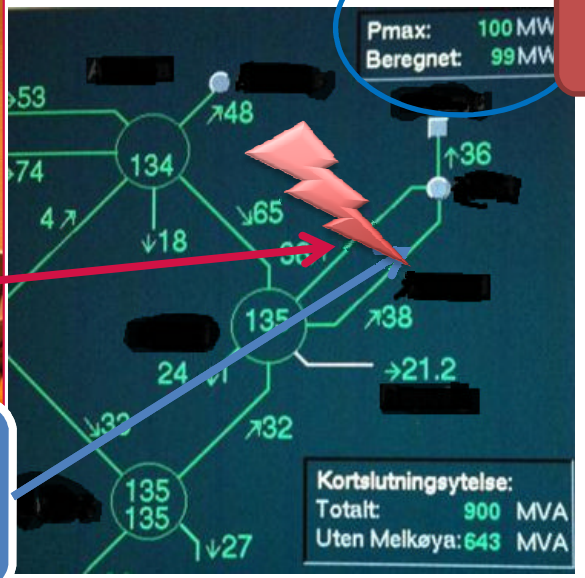


Identify Problems:
iTesla platform allows to perform ***Security Assessment*** to determine challenging dynamic problems

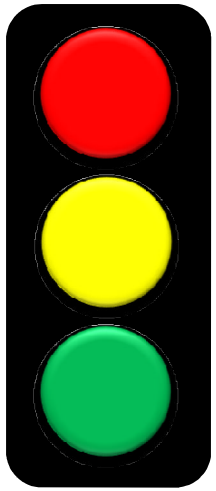
Determine Dynamic Limits:
Security assessment in ***iTesla*** platform also allow to obtain *REALISTIC LIMITS* of stability boundaries

Defense Plan and Actions:
In a dangerous operating state, "Defense Plans" need to act to maintain system integrity.

Restoration Plan and Actions
Perform actions that allow to bring the power system to safe operating state.



Operational State!



Workplan defense / restoration

- Defense plans
  - Strengthes and weaknesses in existing plans (AIA)
  - Pan-European coordination (KU Leuven)
  - Use of PMUs (Statnett / KTH)
  - Use of renewable generation plants (DTU)
  - Use of distributed energy resources (Imperial Col.)
- Restoration
  - Coordinated restoration (AIA)
  - Use of renewable generation plants (INESC)

Coordination control actions and power flow control

Steven De Boeck, Dirk Van Hertem
KU Leuven

Defence plans

- Different influences on the energy flows:
  - Liberalisation which resulted in unbundeling of the power sector
  - Strong increase of renewables in certain regions in Europe
  - Working closer to the limits

  → Cross-border operation of the power system is more **complex** and **international**, and thus there is a need for more **coordination** of power system operation and control of flows.
- Coordinated defence plans:
  - Based on “strengthes and weaknesses in existing plans” – inputs through harmonisation
  - Based on ENTSO-E recommendations for defence plans
  - Ex. Adequate under frequency load shedding schemes : Which Set points, principle of solidarity, Load shedding in each step, disconnection delay,…

Defence plans

- Power flow control:
  - Exploring the use of power flow controlling devices such as PST, FACTS and HVDC
  - Ex. HVDC connection between zones. In case of loss of generation in one zone: increase power injection from the other zone to this zone.
  - Looking at control parameters and how they can be set to let the system return faster to a secure state.
  - How can power flow controllers be used to reduce risk and avoid system collapse

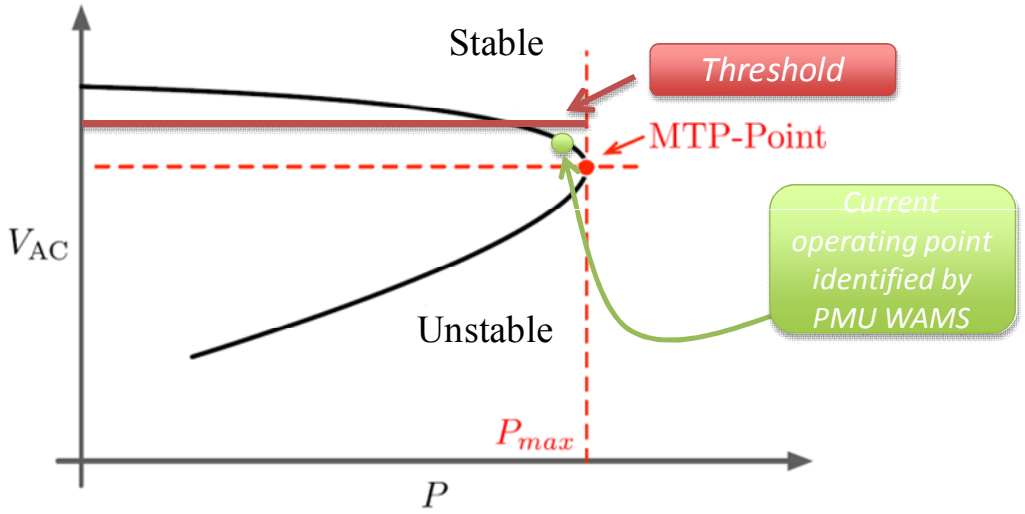
Defensive and restorative Wide Area Control
Use of PMUs in defense plans

Dr. Luigi Vanfretti, Rujiroj Leelaruji, KTH
Jan Ove Gjerde, Senior Vice President, Statnett

Use of PMUs

Restorative Wide-Area Control

A two layer approach for Defense Plans using PMU Data and Controls



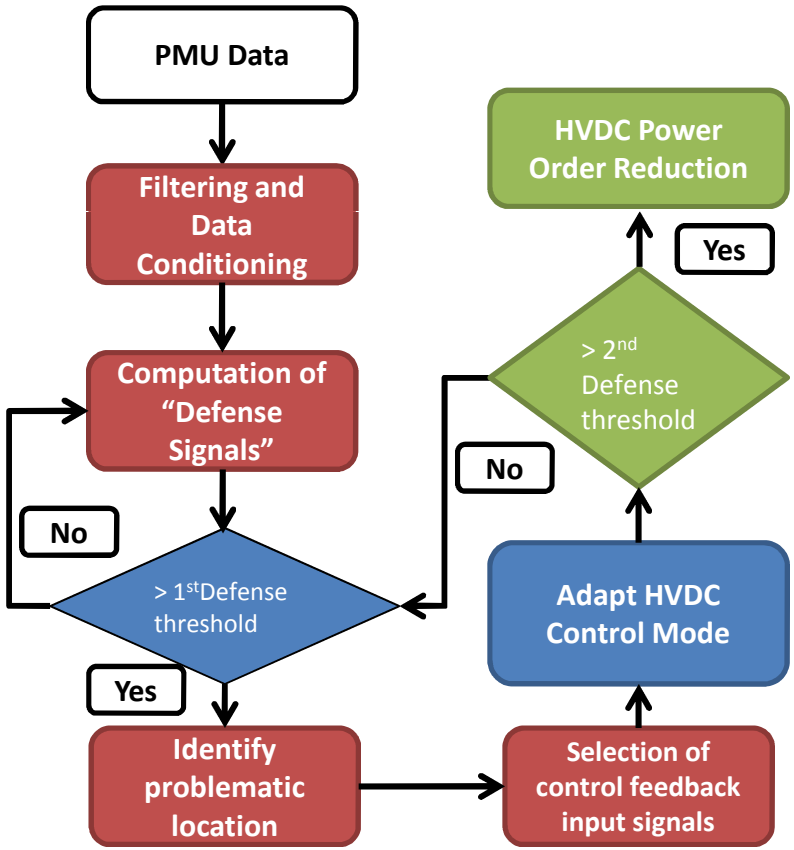
Approaches to prevent a voltage instability in ”defense mode” and ”restorative” mode:

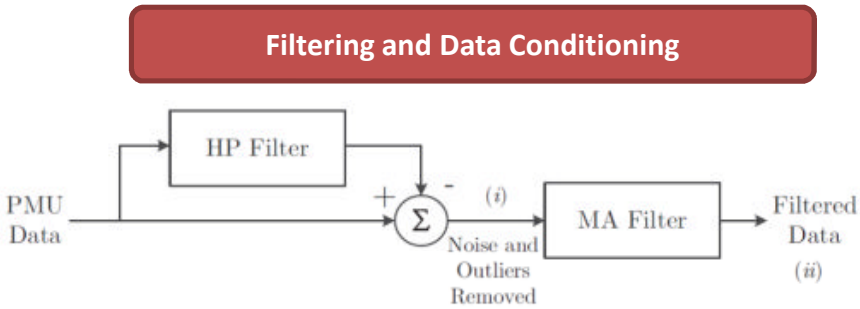
- ***Activate an specific HVDC control mode*** using a ”defense signal” obtained from sensitivities computed from PMU data.
- ***Coordinate with internal HVDC controls:*** *Reduce Power Order of HVDC when surpass MTP-Point.*

Use of PMUs

Generating "Defense Signals" and Activating 2-level Control

To use for modifying HVDC control modes and arming/disarming internal stabilization controllers





Approaches to compute "Defense Signals" obtained from sensitivities computed from PMU data:

- ***Centralized WAMS system to generate global "defense signals"***
- ***Decentralized Real-Time Controllers to activate each control level of the HVDCs***

Use of renewables in defense plans with large amounts of renewable energy sources

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Renewables in defense

- Challenge
  - e.g. high wind / high solar / low consumption:
  - Large scale renewables displace conventional spinning reserves
  - More vulnerable system
- Tasks to study (PhD)
  - understand existing defense plans
  - down regulation or RES during over frequency
  - use positive reserve from downregulated RES during under frequency
  - voltage support during large disturbances
  - virtual inertia and/or changed ROCOF settings
  - power system damping

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Restoration procedures with large amounts of renewable energy sources

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INESC Porto – Power Systems Unit
Leader of iTesla Task TWP6.7

Restoration with RES

- Blackouts are rare but severe events
- Restoration is one of the most important and challenging tasks for power system dispatchers in the control center
  - Off-line restoration plans and available Black Start generation units or interconnections with neighboring areas are used to restore the system

Restoration with RES

- Large scale Integration of renewables, mainly wind (onshore or offshore) 1/2
  - Available resources that can be included in the restoration plan
    - How? When? What are the control requirements?
    - Off-shore wind generators and the development of Multi Terminal DC grids with Voltage Source Converters offer flexible control functionalities that can be exploited in the restoration phase

Restoration with RES

- Large scale Integration of renewables, mainly wind (onshore or offshore) 2/2
  - Load-frequency control during the load pick-up phase, including active participation of wind generators
  - Increase the amount of restored load and reduce the restoration times

Thank you

- Questions?

  - Workplan defense / restoration
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